NATIONAL BUREAU OF STANDARDS REPORT

10 269

~~Not for publication or for reference.~~

Progress Report On

THE PERFORMANCE OF INDUSTRIAL-TYPE PROTECTED METAL BUILDING SHEETS

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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THE PERFORMANCE OF INDUSTRIAL-TYPE PROTECTED METAL BUILDING SHEETS

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by
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to

Office of the Chief of Engineers, U. S. Army
Directorate of Civil Engineering, U. S. Air Force
Naval Facilities Engineering Command; U. S. Navy

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NATIONAL BUREAU OF STANDARDS

Progress Report on

The Performance of Industrial-Type Protected Metal Building Sheets

by

Joseph W. Pitts

I. Introduction

The objectives of this project are to obtain laboratory and weathering exposure data on the performance and durability of coil-coated, roll-formed, industrial-type protected metal building sheets and to determine if correlations exist between the laboratory results and service behavior. The project is designed to use existing test methods and techniques and where necessary to develop new tests that will predict the long-term in-service performance of protected metal building sheets on the basis of short-term tests and to provide reliable test results that can be used for specifying appropriate materials of this type for industrial use.

The objectives of the project are being accomplished by (1) performing accelerated laboratory tests on representative samples of materials, (2) determining the weathering behavior of replicate specimens of these materials by exposing them at the seven NBS outdoor exposure test sites, and (3) conducting field surveys of existing buildings to assess the behavior of protected metal building sheets under varying field conditions and for varying times. The data accumulated from these three sources will be analyzed to determine what correlations, if any, exist between short-term laboratory tests and long-term service performance.

This report is a summary of the first year's activities on this program.

II. Materials

A survey was made of all companies known to be producers of factory-applied, organic-coated industrial-type building sheets. Each company was contacted by telephone or by letter and asked to submit complete descriptions of their candidate materials. After receipt of this information, one or more products was selected to represent each different type of coating on substrates of both

aluminum and galvanized steel. The companies involved were requested to send samples of their regular production-run stock. For the purpose of the program the materials are divided into three categories as follows:

1. Liquid process coating: One or more films of a synthetic resin coating material applied as a liquid to the metal substrate, then cured by baking.

2. Dry film laminate: A dry film coating material bonded to the metal substrate with an adhesive.

3. "Protected Metal": Galvanized steel coated with a relatively thick coating consisting of an asphaltic material and an inert mineral.

Table 1 shows the types of coatings included in the program and the code number of each different lot of sample material received. Throughout this report materials are classified by the generic name of the coating (as in Table 1) and are identified by code numbers rather than by company trade names.

Nearly all materials were received in the shape of preformed panels, but a few were received as flat sheets. These latter samples, however, were bent into panel-type profiles before placing on outdoor exposure. Materials were received at various stages throughout the first year of this program; therefore, where test data are lacking, it is because of the late arrival of samples. Table 2 gives detailed information on all materials received.

III. Outdoor Exposure

As soon as sample materials were received, first priority was given to getting specimens out on exposure at the test sites. These outdoor exposure test sites were established by the Materials Durability and Analysis Section of the Building Research Division and are located at Federal Government installations scattered throughout North America. The locations of the sites together with the types of climates and environments represented are listed as follows:

1. NBS, Gaithersburg, Maryland---Rural

2. Fort Holabird, U. S. Army, Baltimore, Maryland---Industrial

3. U.S. Naval Station, Roosevelt Roads, Puerto Rico---Tropical

4. Nellis Air Force Base, Las Vegas, Nevada---Desert

5. Fort Lewis, U. S. Army, Tacoma, Washington---Temperate, Heavy Rainfall

6. Fort Greely, U. S. Army, Fairbanks, Alaska---Sub-arctic

7. U.S. Coast Guard Station, Cape May, New Jersey---Marine
   Lot A: 80 ft. from ocean - frequent ocean spray
   Lot B: 800 ft. from ocean - remote from spray

Five of the seven sites were provided by the Department of Defense and, as noted above, are located on installations of the three military services. One site, with two lots, was provided by the Coast Guard (U. S. Department of Transportation) and one site is on the grounds of NBS.

The weathering study specimens are two feet long, measured in the direction of the original panel length. Panels wider than 12 inches (which most are) are cut into specimens about 10 to 12 inches wide, and in all cases specimens include at least four bends in the metal. The number of specimens of each material exposed at each site varies from 1 to 3 depending on the quantity of material received and space available at the site. Specimens are exposed at all sites in the vertical position and face equatorial south.

IV. Laboratory Tests

1. Salt Spray (Fog) Test

Two specimens, 3 x 8 inches, of each material were subjected to 1500 hours of 5% salt spray in accordance with ASTM B-117. One specimen of each pair was exposed with unprotected edges and, also, across the face of this specimen two diagonal lines in the form of an "X" were scratched through the coating to the base metal. The other specimen of each pair was unscratched and in addition, the cut edges of the steel specimens were protected with a coating of wax.

Examinations and analyses of both sets of specimens were made after their removal from the salt spray cabinet at the end of the 1500 hour period. Comparative ratings are shown in Table 3, where a rating of "1" indicates the best resistance to the salt spray and a rating of "10" indicates the poorest resistance. The "Surface" rating indicates the behavior of the coating in those areas remote from an edge or a scratch. The "Edge" rating is based on the behavior of the metal and coating at cut edges and adjacent to the scratched "X". The criteria for the ratings are based on the degree of blistering and peeling of the coating and on corrosion of the substrate metal.

2. Cyclic Condensation Test

This test developed by the Cleveland Paint Society subjects specimens to alternate cycles of condensation of heated distilled water and forced hot air drying. Specimens are placed face down on an inclined rack over a pan of heated water; the angle of the specimens is such that moisture condensing on the specimens drains off and runs back into the reservoir. At the end of the preset condensing period the specimens are dried by a flow of warm air. The apparatus used in this test is manufactured by the Q-Panel Company and sold under the name of "Q-C-T Cyclic Environmental Tester".

One specimen, 2 x 8 inches, of each material was tested for 1500 hours, with a continuous cycle setting of one hour condensing and one hour drying. Specimens were not scribed and the edges of the galvanized steel specimens were protected with a wax coating. After removal from the test, specimens were measured for color and gloss changes and the results are tabulated in Table 4.

3. Weatherometer Test

One specimen of each material was tested in each of two Weatherometers: one a single carbon arc and the other a twin carbon arc. The single carbon arc Weatherometer was operated on a 20-hour day, 5-day week basis with the light cycling between one hour on and one hour off. A continuous water spray on the back of the rotating drum (but not on the specimens) maintained the relative humidity between 95 and 100%.

The twin arc apparatus was operated in accordance with Federal Test Method Standard No. 141a, Method 6152 and ASTM D-822; e.g., 5-day week, 20-hour day, 2-hour cycle in which specimens are exposed for 102 minutes to light only, then 18 minutes of light with water spray directly on the specimens.

After 1000 hours of light time in each of the Weatherometers, specimens were removed and measured for color and gloss changes. The results for those specimens that have completed these tests are shown in Table 4.

4. Abrasion Resistance

Measurements of abrasion resistance were made with the Roberts Jet Abrader [1,2]. The Roberts Jet Abrader measures the abrasion resistance of coatings in terms of the time required for a closely controlled jet of fine abrasive particles to penetrate the coating. The end-point, which is determined visually by the operator, is a change in appearance of the abraded spot that occurs when the substrate material becomes exposed. The substrate is distinguished by a change in color or reflectivity and usually first appears as a small spot in the center of the abraded area of the coating (approximately 1/8 inch in diameter).

The apparatus permits variations of four parameters: pressure of the gas (CO_2) carrying the abrasive particles, distance and angle between outlet nozzle and specimen, and quantity of abrasive particles (controlled by voltage on abrasive reservoir vibrator). For the current measurements these parameters were set respectively at 30 psi, 0.8 inch, 90°, and 30v.

The results are shown in Table 4 in terms of the number of seconds required to penetrate the coating through to the substrate metal (or to the zinc coating in the case of galvanized steel). The times shown are actual times, uncorrected for variations in thickness.

[1] "Abrasive Jet Method for Measuring Abrasion Resistance of Organic Coatings", A. G. Roberts, W. A. Crouse, and R. S. Pizer, ASTM Bulletin, No. 208, Sept. 1955, pp 36-41.

[2] "Improved NBS Abrasive Jet Method for Measuring Abrasion Resistance of Coatings", A. G. Roberts, ASTM Bulletin, No. 244, Feb. 1960, pp 48-51.

V. Observations and Conclusions

1. Salt Spray - All of the coating types appeared to be chemically resistant to the salt spray. The few failures observed occurred at pinhole imperfections in the coatings, which allowed the salt solution to contact and corrode the metal substrate, resulting in coating blisters.

2. Cyclic Condensation - The cyclic condensation test had very little or no effect on most coatings and only a minor effect on those few where the measurements indicated there may be significant changes. Only one coating showed a visually detectable color change - 1.9 NBS Units (a change of 1 NBS Unit is not visually detectable). Also, only one showed a large percentage loss of gloss, but this one was extremely low in gloss initially, therefore, the practical effect of the change is negligible.

3. Weatherometer - The Weatherometer tests had significant effects on nearly all coatings and of the two Weatheromter types, the twin-arc appears to be the more aggressive. All except one coating lost glass in the twin-arc, and some of the losses were quite severe. In general, color changes were quite small; however, four coatings did undergo detectable changes (2 NBS Units or more).

4. Abrasion - The fluoropolymers are vastly superior in abrasion resistance to the polyesters, acrylics, vinyls, and alkyds and are as good or better than the "protected metals" even when measurements are uncorrected for thickness differences. One liquid process acrylic (Material Number 15) did show a very high abrasion resistance, but because this one is so very different from the others of its class, the assumption is made that the material was mislabelled.

The dry film coatings appear to be superior to their wet process counterparts, but at least part of this increased abrasion resistance can be attributed to the greater total thickness (film plus adhesive).

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Table 1. Coating types and metal substrates included in program. Each number in the "Metal" columns indicates a different lot of material, either from the same company or a different company.

COATING	METAL	
	GALVANIZED STEEL	ALUMINUM
LIQUID PROCESS		
Fluoropolymer	10,12,17,25	8,16,22,28
Siliconized Polyester	2,3,4,7,24	6
Acrylic	11,15	14,18
Vinyl		19,20,21
Siliconized Acrylic		5
Alkyd*	1	
DRY FILM LAMINATE		
Fluoropolymer*		23
Acrylic	13	
PROTECTED METAL		
Polyester finish on asphalt-saturated asbestos	9	
Flake mica finish on asphalt	26	
Acrylic finish on asphalt-mica	27	

*Very small sample available

Table 2. Descriptions of Materials

NO.	METAL			COATING		
	TYPE*	THICKNESS (mils)	TEXTURE	TYPE	APPROXIMATE THICKNESS (mils)	COLOR
10	GS	36	Smooth	Fluoropolymer	1	Green
12	GS	27	"	"	1	Brown
17	GS	31	"	"	1	Blue
25	GS	27	"	"	1	Brown
8	A	32	Embossed	"	1	Blue
16	A	39	Smooth	"	1	Black
22	A	34	Embossed	"	1	White
28	A	43	"	"	1	Tan
2	GS	24	Smooth	Silic.-Polyester	1	Tan
3	GS	18	"	"	1	Brown
4	GS	20	"	"	1	Green
7	GS	40	Embossed	"	1	Tan
24	GS	28	Smooth	"	1	Gray
6	A	32	Embossed	"	1	Tan
11	GS	29	Smooth	Acrylic	1	Gray
15	GS	48	"	"	1.5	Coral
14	A	38	"	"	1	Coral
18	A	21	Embossed	"	1	Green
19	A	32	"	Vinyl	1	Tan
20	A	32	"	"	1	Blue
21	A	32	"	"	1	Gray
5	A	32	"	Silic.-Acrylic	1	Brown
1	GS	48	Smooth	Alkyd	1.5	Green
23	A	21	"	Fluoropol.-Lam.	2	Tan
13	GS	22	"	Acrylic-Lam.	2	Blue
9	GS	24	"	Polyes.-Asphalt-Asbes.	10	Tan
26	GS	36	"	Mica-Asphalt	12	Silvery
27	GS	36	"	Acrylic-Mica-Asphalt	10	Maroon

*GS - Galvanized Steel; A - Aluminum

Table 3. Results of 1500 hours in 5% salt spray test. Specimens are rank-rated numerically, with a rating of "1" indicating best resistance to the salt spray and a rating of "10" indicating poorest resistance.

NO.	COATING	ALUMINUM		STEEL	
		SURFACE	EDGE	SURFACE	EDGE
8	Fluoropolymer	1	1		
16	"	2	4		
22	"	1	1		
10	"			1	10
12	"			3	9
17	"			2	10
6	Siliconized Polyester	1	2		
2	"			1	10
3	"			2	9
4	"			2	9
7	"			2	7
14	Acrylic	1	3		
18	"	1	1		
11	"			3	8
15	"			1	9
19	Vinyl	1	1		
20	"	1	1		
21	"	2	2		
1	Alkyd			1	10
5	Siliconized Acrylic	2	3		
13	Acrylic Laminate			1	9
9	Polyester on Asphalt-Asbestos			2	5

Table 4. Results of Abrasion Resistance, Cyclic Condensation (cc), and Weatherometer (W-1 = Single arc; W-2 - Twin arc)

NO.	COATING	ABRASION (sec)	INITIAL GLOSS	FINAL GLOSS cc	FINAL GLOSS W-1	FINAL GLOSS W-2	COLOR CHANGE (NBS Units) cc	COLOR CHANGE (NBS Units) W-1	COLOR CHANGE (NBS Units) W-2
10	Fluoropolymer	13.8	29.8	29.5	---	19.8	0.7	---	0.5
12	"	16.3	23.8	23.4	---	21.2	0.1	---	0.4
17	"	9.3	29.7	29.5	---	25.0	0.6	---	0.8
25	"	13.1	---	---	---	---	---	---	---
8	"	15.0	10.5	10.2	10.1	7.3	0.4	0.5	0.8
16	"	14.3	25.8	25.2	---	23.6	0.2	---	1.6
22	"	9.2	12.0	12.0	---	10.4	0.5	0.5	0.4
28	"	16.8	---	---	---	---	---	---	---
2	Silic.-Polyes.	1.4	25.9	22.2	---	10.2	1.2	---	0.6
3	"	1.3	25.1	23.0	18.5	8.2	0.3	0.8	1.1
4	"	1.5	21.5	21.2	---	11.3	0.3	---	1.2
7	"	1.6	12.7	12.0	10.0	7.0	0.4	1.1	0.6
24	"	1.0	---	---	---	---	---	---	---
6	"	2.1	10.6	9.4	10.5	8.3	0.1	---	0.2
11	Acrylic	2.4	15.6	14.3	9.3	10.4	1.9	0.6	1.6
15	"	19.2	26.3	26.3	---	20.0	0.2	---	1.3
14	"	1.7	31.6	31.1	---	31.4	0.4	---	0.8
18	"	1.7	17.9	17.3	---	10.3	0.4	---	2.0
19	Vinyl	3.0	20.4	20.2	---	16.2	0.6	---	0.2
20	"	3.1	27.4	27.4	---	4.8	0.9	---	2.1
21	"	4.1	28.8	28.4	---	3.5	0.2	---	2.6
5	Silic.-Acrylic	1.8	14.3	14.2	9.2	10.3	0.5	1.6	2.2
1	Alkyd	1.3	22.8	22.7	---	17.2	1.1	---	1.5
23	Fluoropol.-Lam.	28.5	---	---	---	---	---	---	---
13	Acrylic-Lam.	9.6	41.3	41.1	---	30.5	0.9	---	0.9
9	Polyes. on Asphalt	9.6	5.2	2.5	2.2	3.6	1.4	0.9	1.0
26	Mica on Asphalt	9.2	---	---	---	---	---	---	---
27	Acrylic on Asphalt	12.4	---	---	---	---	---	---	---

Identification of Materials Listed in NBS Report 10 269

Mat'l No.	Manufacturers and/or Supplier	Trade Name
1	Inland-Ryerson	Duofinish
2	Inland-Ryerson	Duofinish
3	Inland-Ryerson	Duofinish
4	Ceco Corporation	Rib-Drain
5	Reynolds Metals	Colorweld
6	H. H. Robertson	Durasil
7	H. H. Robertson	Durasil
8	Reynolds Metals	Colorweld (Fluoropon)
9	H. H. Robertson	Galbestos
10	Pennwalt Corporation	Kynar 500
11	Bowman Building Products	Galv-Plus
12	Inland-Ryerson	Duofinish 500
13	Rohm & Haas (Dixiesteel)	Korad A
14	Elwin G. Smith	Colorgard II
15	Elwin G. Smith	Colorgard II
16	Elwin G. Smith	Kynar II
17	Elwin G. Smith	Kynar II
18	Aluminum Company of America	Tone Coat
19	Aluminum Company of America	Alumalure
20	Aluminum Company of America	Alumalure
21	Aluminum Company of America	Alumalure
22	Reynolds Metals	Colorweld (Du-Lite)
23	Alsco	Tedlar
24	Plasteel Products Corporation	Duraclad V
25	Plasteel Products Corporation	Duraclad XX (Kynar)
26	Plasteel Products Corporation	Protected Metal
27	Plasteel Products Corporation	Protected Metal - Color Clad
28	DuPont (Brinkley Company)	Du-Lite

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